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INT CL⁴ H01Q

(54) **Method and apparatus for the simultaneous generation of several real-time controllable aerial diagrams**

(57) In a method for the simultaneous generation of several real-time controllable aerial diagrams, an aerial, which consists of several directly-radiating active microwave emitters, is used and the microwave emitters are operated by an optical beam-forming network.

The method enables several real-time controllable aerial lobes to be generated. Neither the transmitter system, nor, in particular, the receiver system, are made up of microwave components, but with optical and electro-optical components. For this reason, the arrangement is compact and light.

Fig. 5

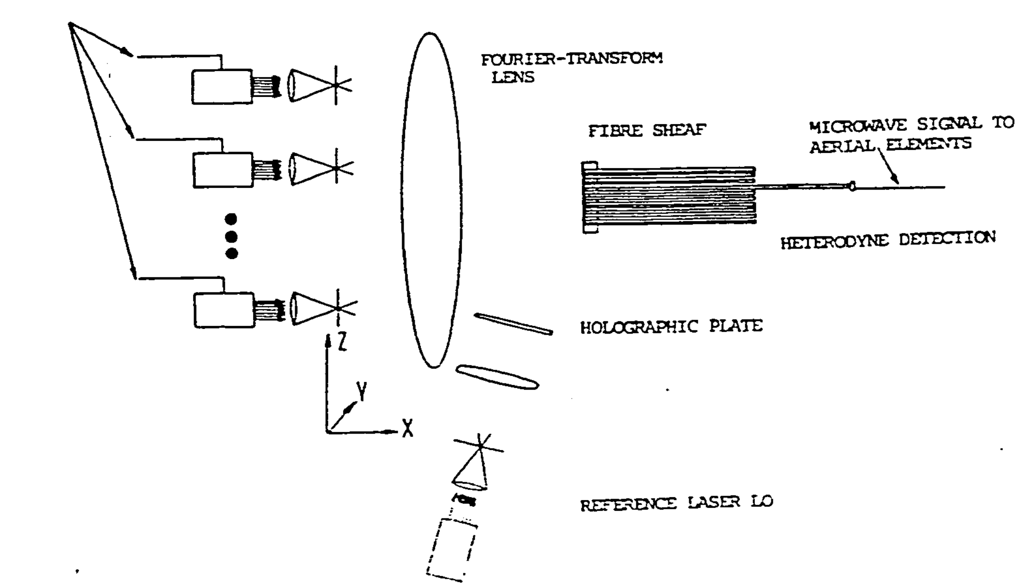

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Fig.1

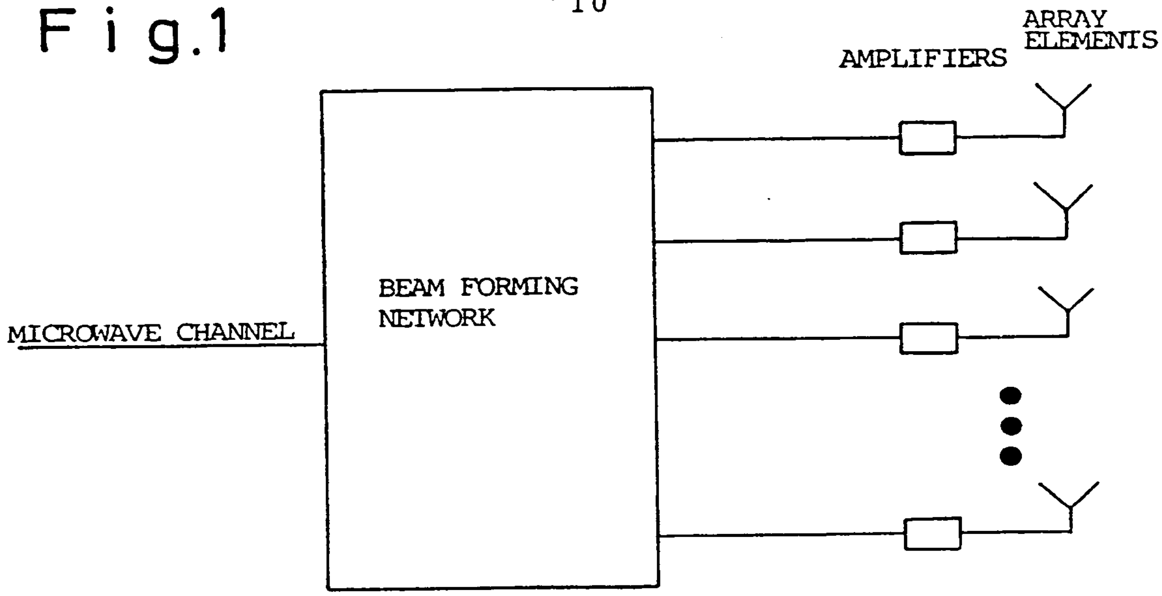
ARRAY ELEMENTS
AMPLIFIERS
BEAM FORMING NETWORK
MICROWAVE CHANNEL

Fig.2

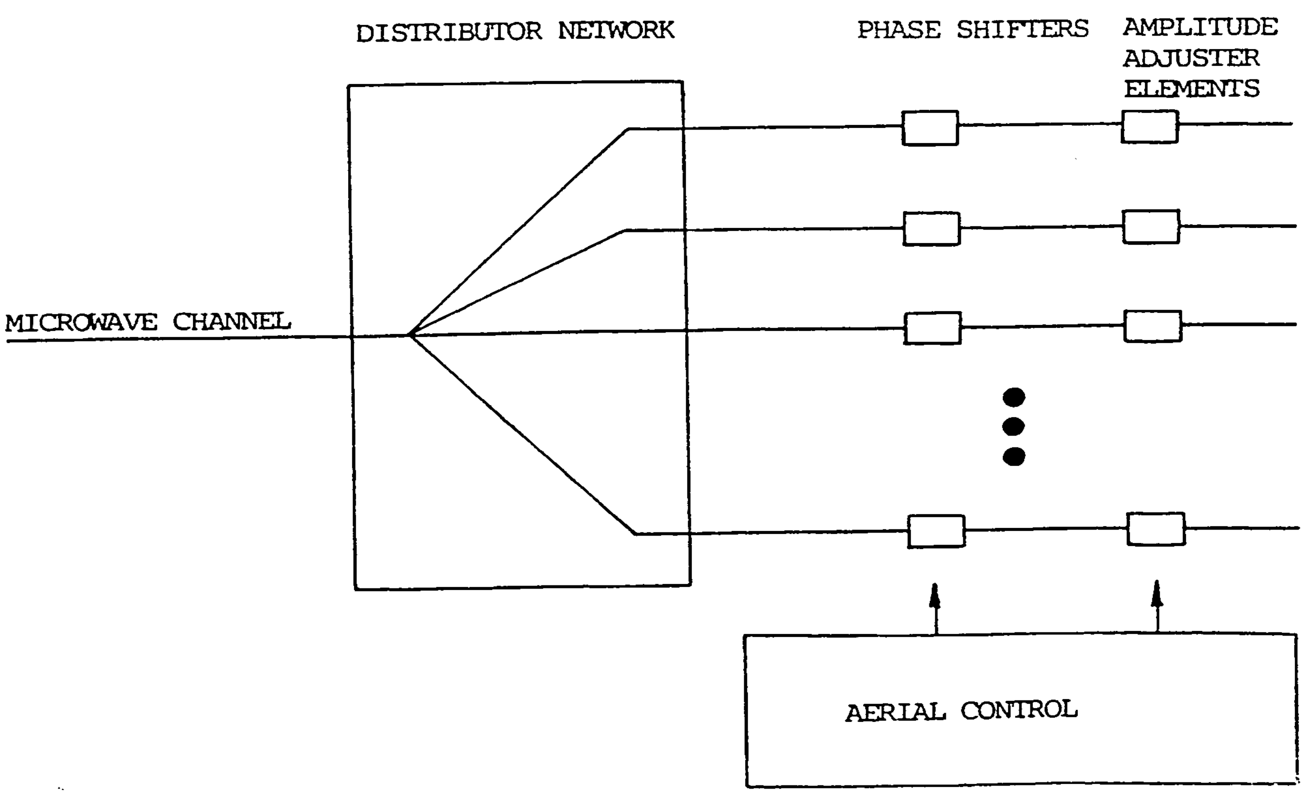
DISTRIBUTOR NETWORK
PHASE SHIFTERS
AMPLITUDE ADJUSTER ELEMENTS
MICROWAVE CHANNEL
AERIAL CONTROL

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Fig.3

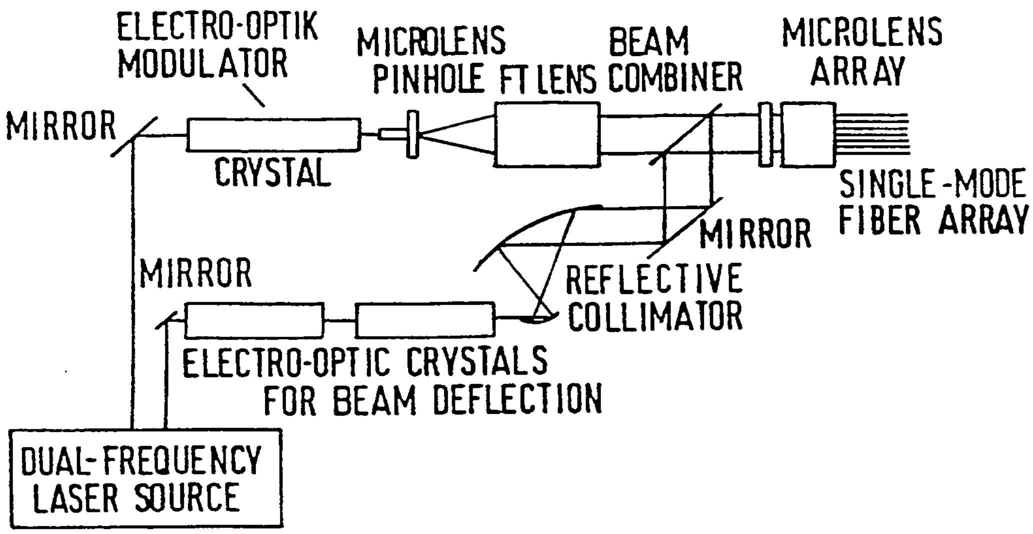
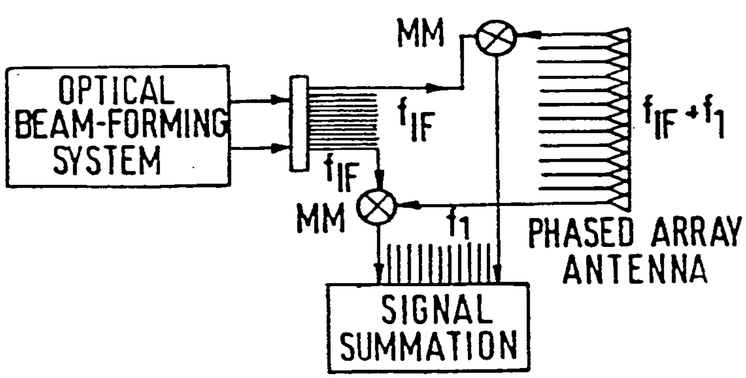


Fig.4



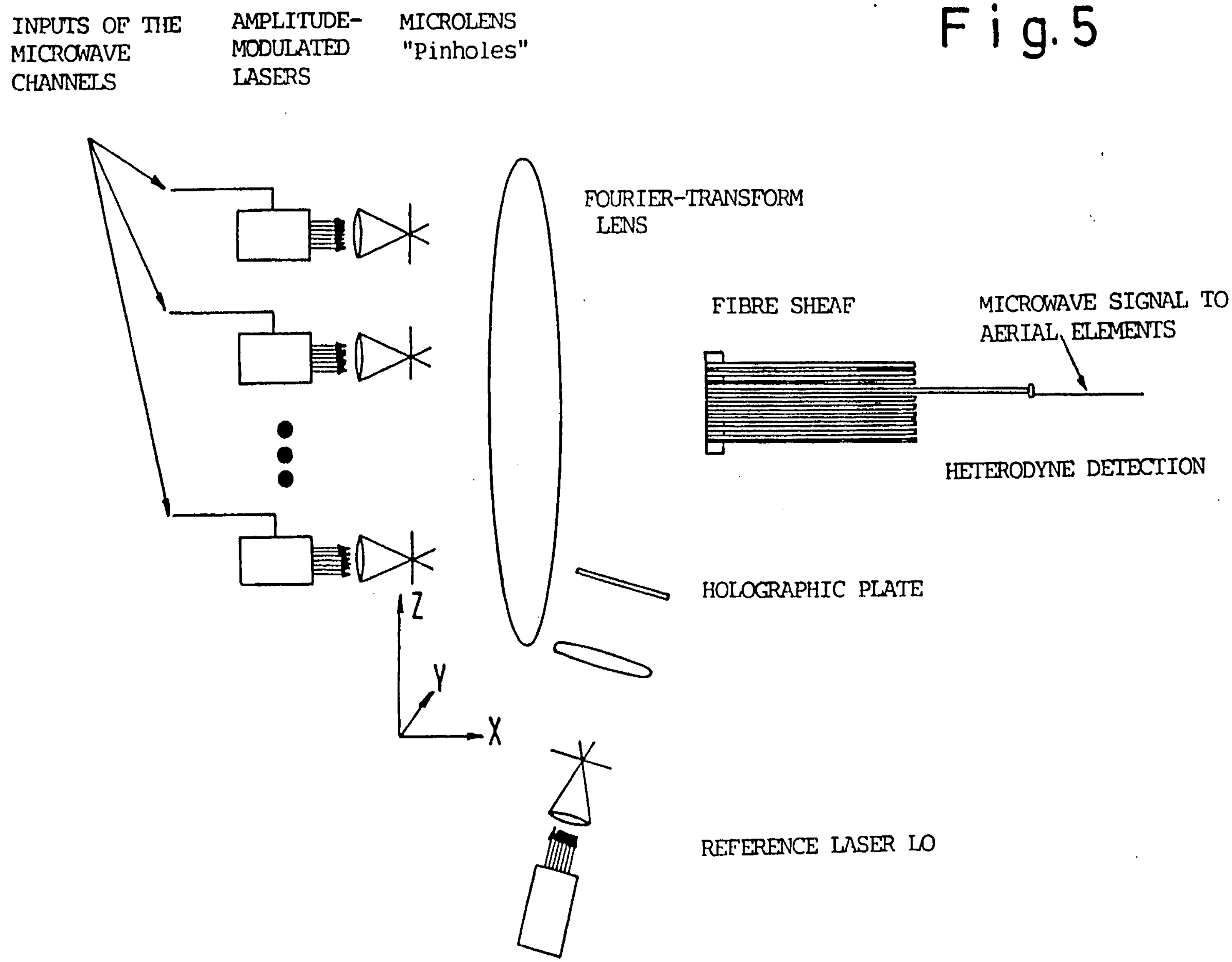

INPUTS OF THE MICROWAVE CHANNELS
AMPLITUDE-MODULATED LASERS
MICROLENS "Pinholes"
FOURIER-TRANSFORM LENS
FIBRE SHEAF
MICROWAVE SIGNAL TO AERIAL ELEMENTS
HETERODYNE DETECTION
HOLOGRAPHIC PLATE
REFERENCE LASER LO
Z
Y
X

Fig.5

Fig.6

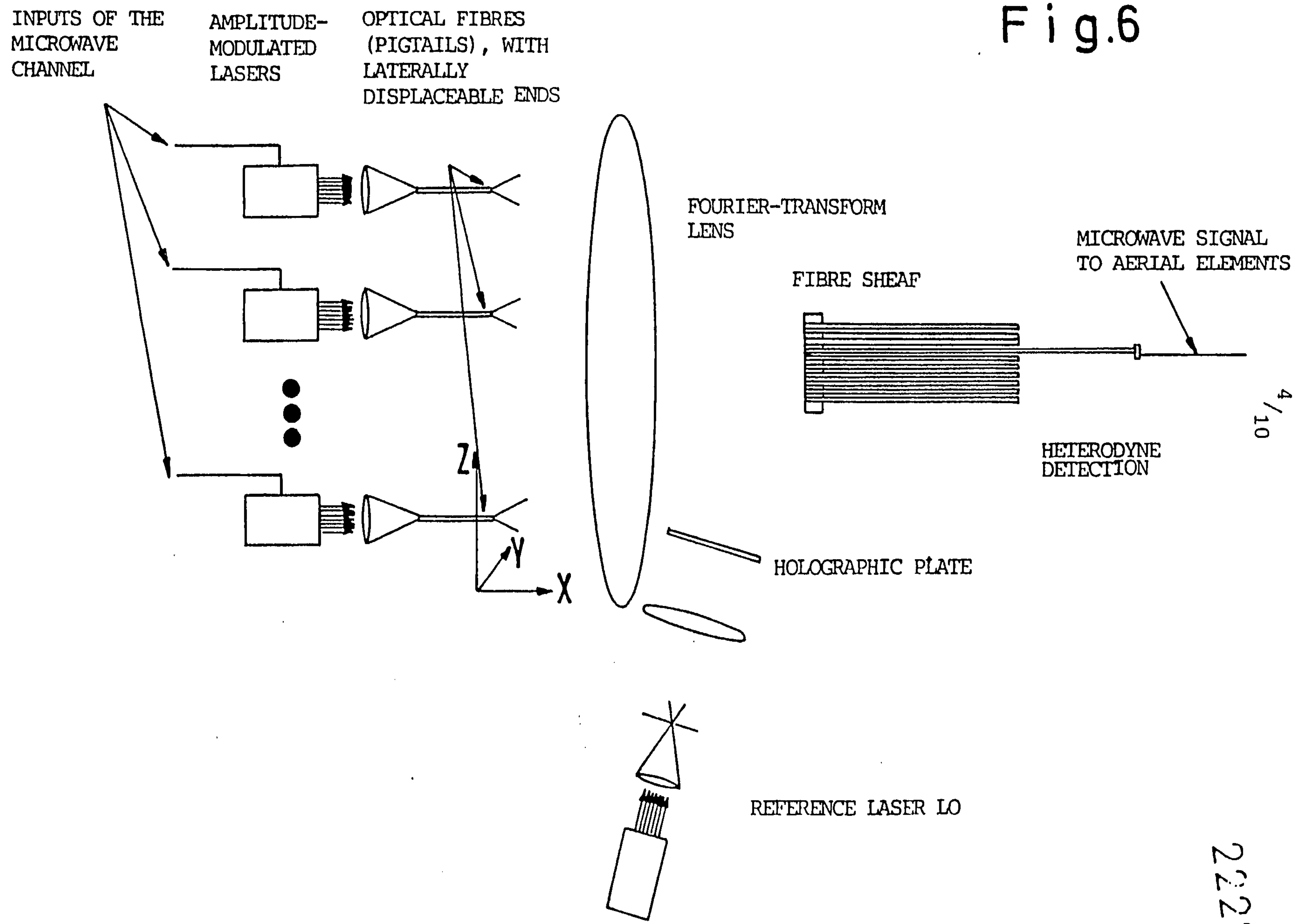
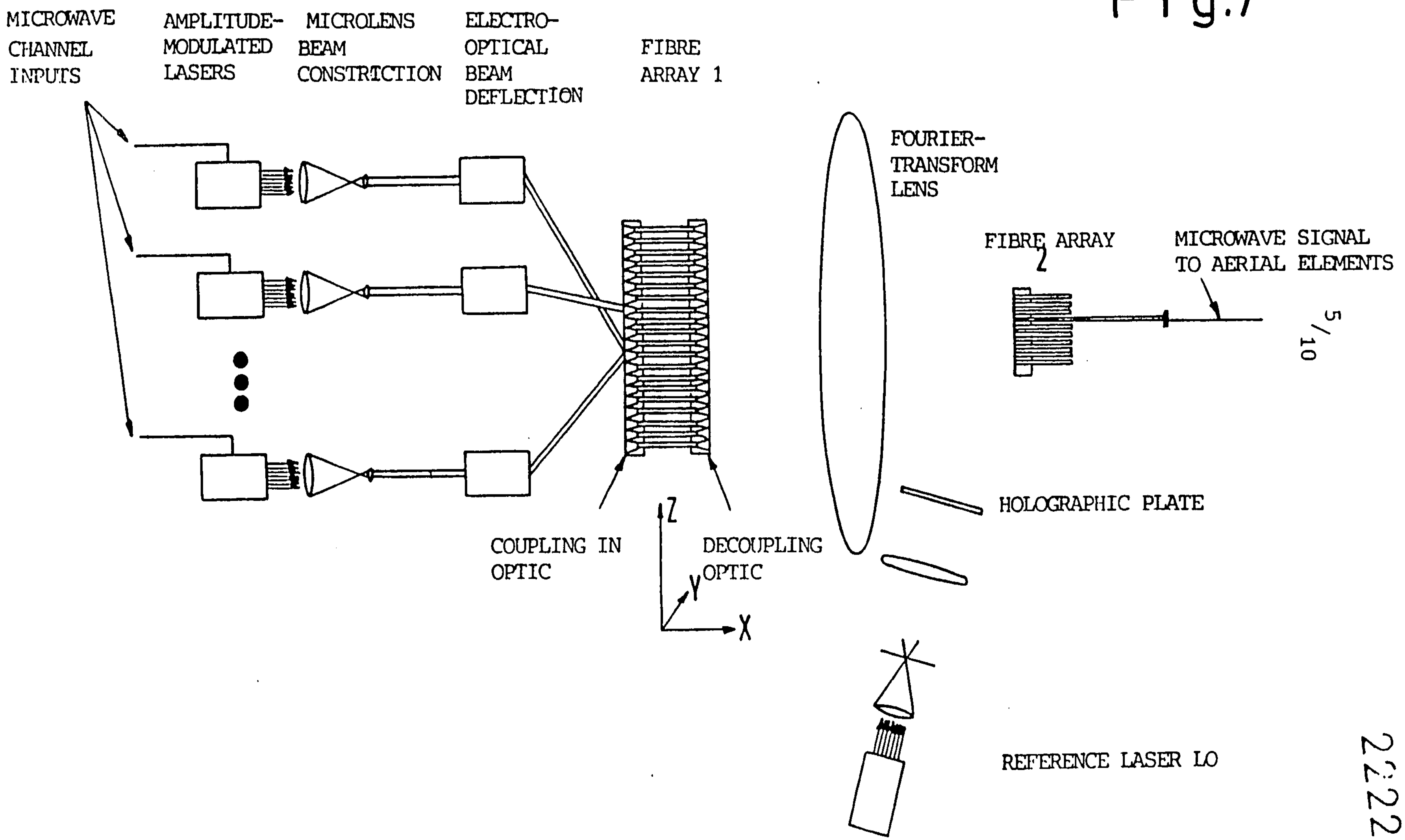
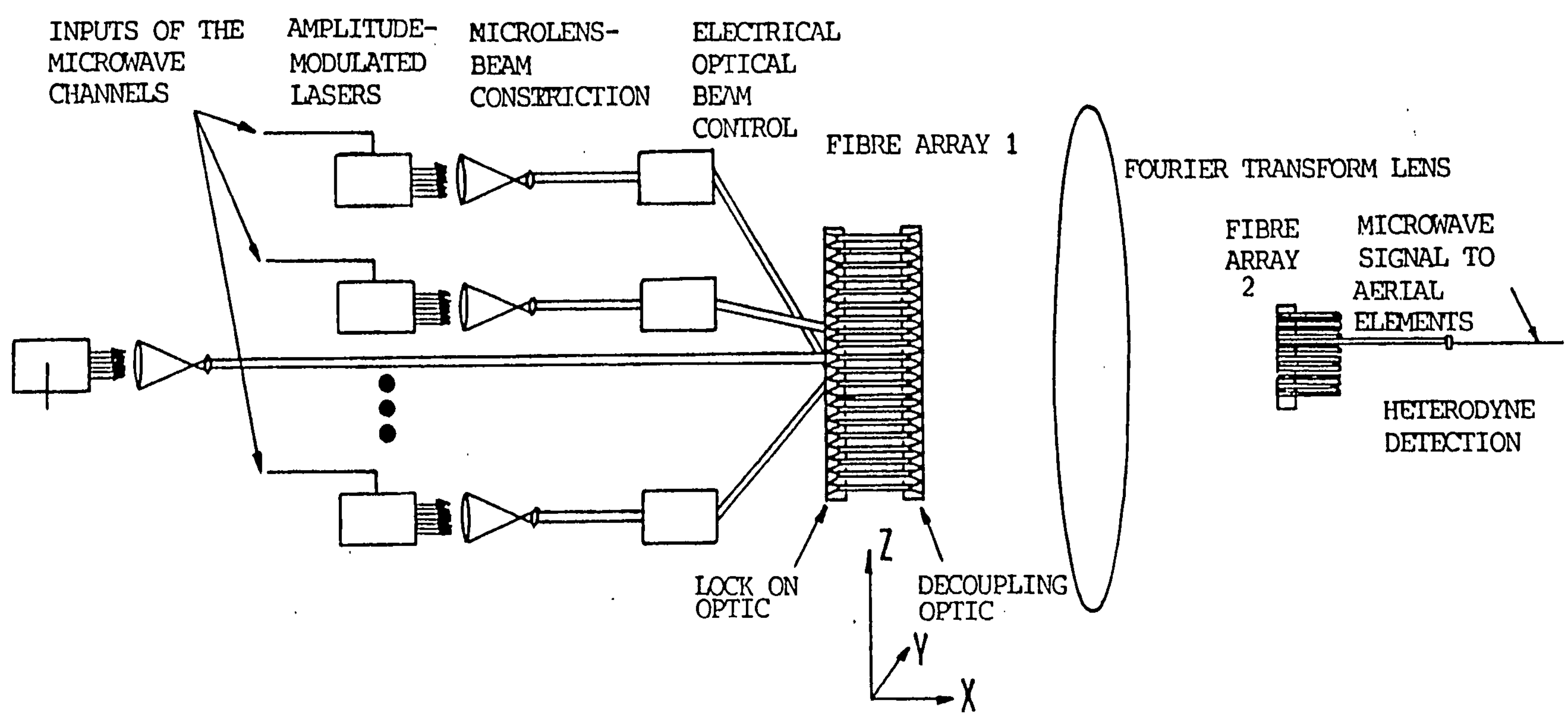

INPUTS OF THE MICROWAVE CHANNEL
AMPLITUDE-MODULATED LASERS
OPTICAL FIBRES (PIGTAILS), WITH LATERALLY DISPLACEABLE ENDS
Z
Y
X
FOURIER-TRANSFORM LENS
FIBRE SHEAF
MICROWAVE SIGNAL TO AERIAL ELEMENTS
HETERODYNE DETECTION
HOLOGRAPHIC PLATE
REFERENCE LASER LO

Fig.7



MICROWAVE CHANNEL INPUTS
AMPLITUDE-MODULATED LASERS
MICROLENS BEAM CONSTRICTION
ELECTRO-OPTICAL BEAM DEFLECTION
FIBRE ARRAY 1
COUPLING IN OPTIC
DECOUPLING OPTIC
Z
Y
X
FOURIER-TRANSFORM LENS
FIBRE ARRAY 2
MICROWAVE SIGNAL TO AERIAL ELEMENTS
HOLOGRAPHIC PLATE
REFERENCE LASER LO

Fig.8


INPUTS OF THE MICROWAVE CHANNELS
AMPLITUDE-MODULATED LASERS
MICROLENS-BEAM CONSTRICTION
ELECTRICAL OPTICAL BEAM CONTROL
FIBRE ARRAY 1
FOURIER TRANSFORM LENS
FIBRE ARRAY 2
MICROWAVE SIGNAL TO AERIAL ELEMENTS
HETERODYNE DETECTION
LOCK ON OPTIC
DECOUPLING OPTIC
Z
Y
X

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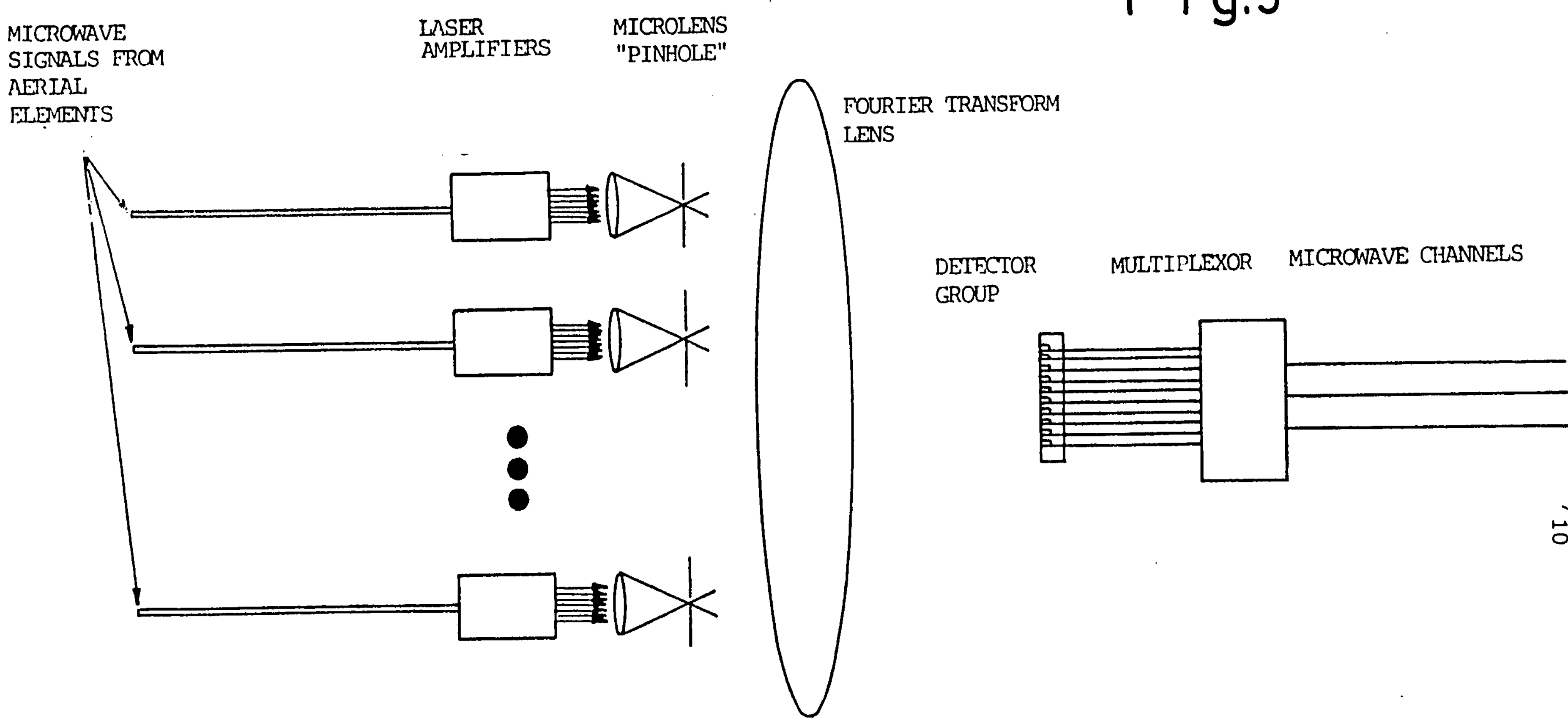


Fig.9

Fig.10

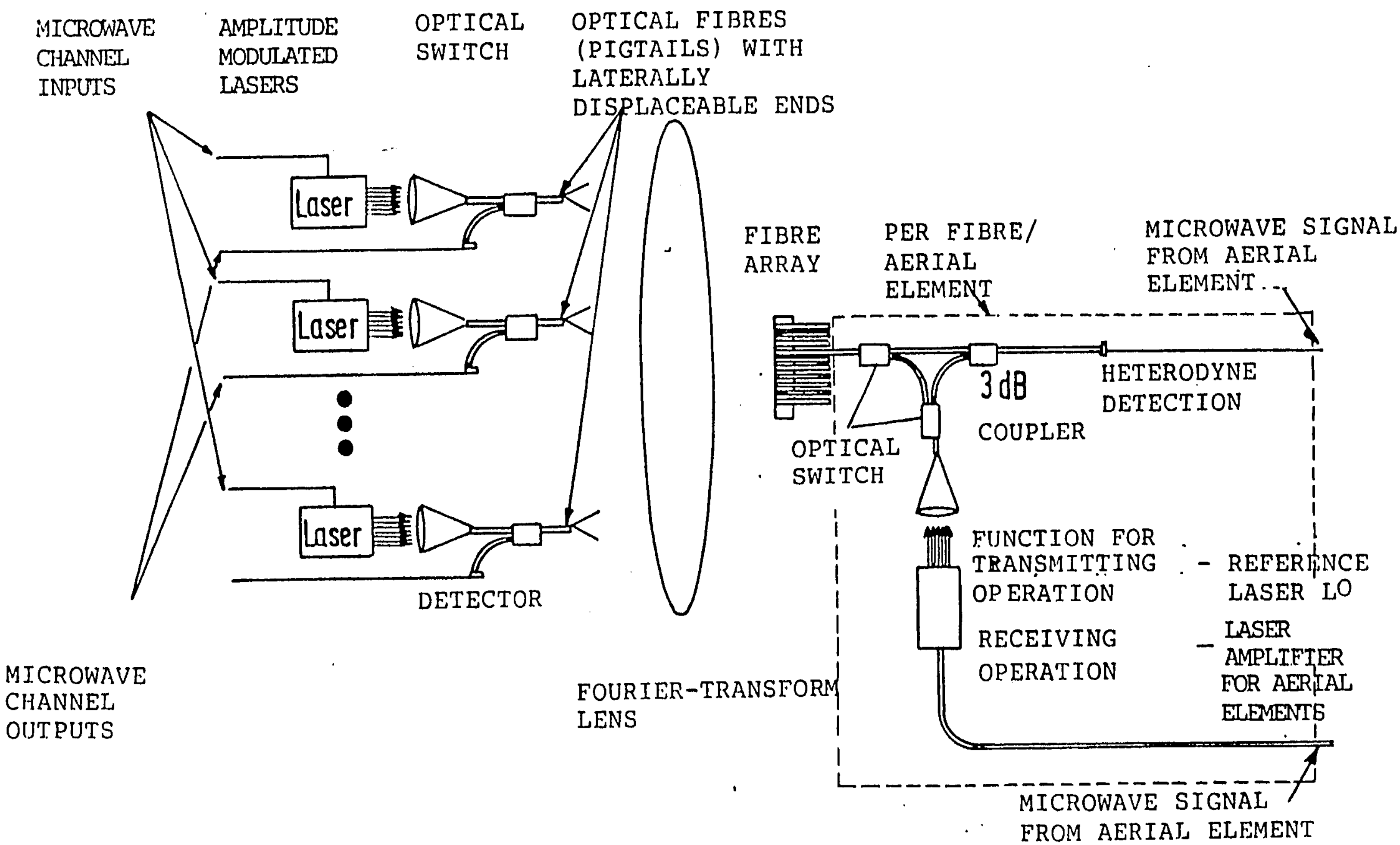

MICROWAVE CHANNEL INPUTS
AMPLITUDE MODULATED LASERS
OPTICAL SWITCH
OPTICAL FIBRES (PIGTAILS) WITH LATERALLY DISPLACEABLE ENDS
Laser
Laser
Laser
DETECTOR
MICROWAVE CHANNEL OUTPUTS
FOURIER-TRANSFORM LENS
FIBRE ARRAY
PER FIBRE/ AERIAL ELEMENT
MICROWAVE SIGNAL FROM AERIAL ELEMENT
3dB
COUPLER
HETERODYNE DETECTION
OPTICAL SWITCH
FUNCTION FOR TRANSMITTING OPERATION
RECEIVING OPERATION
- REFERENCE LASER LO
- LASER AMPLIFIER FOR AERIAL ELEMENTS
MICROWAVE SIGNAL FROM AERIAL ELEMENT

Fig.11

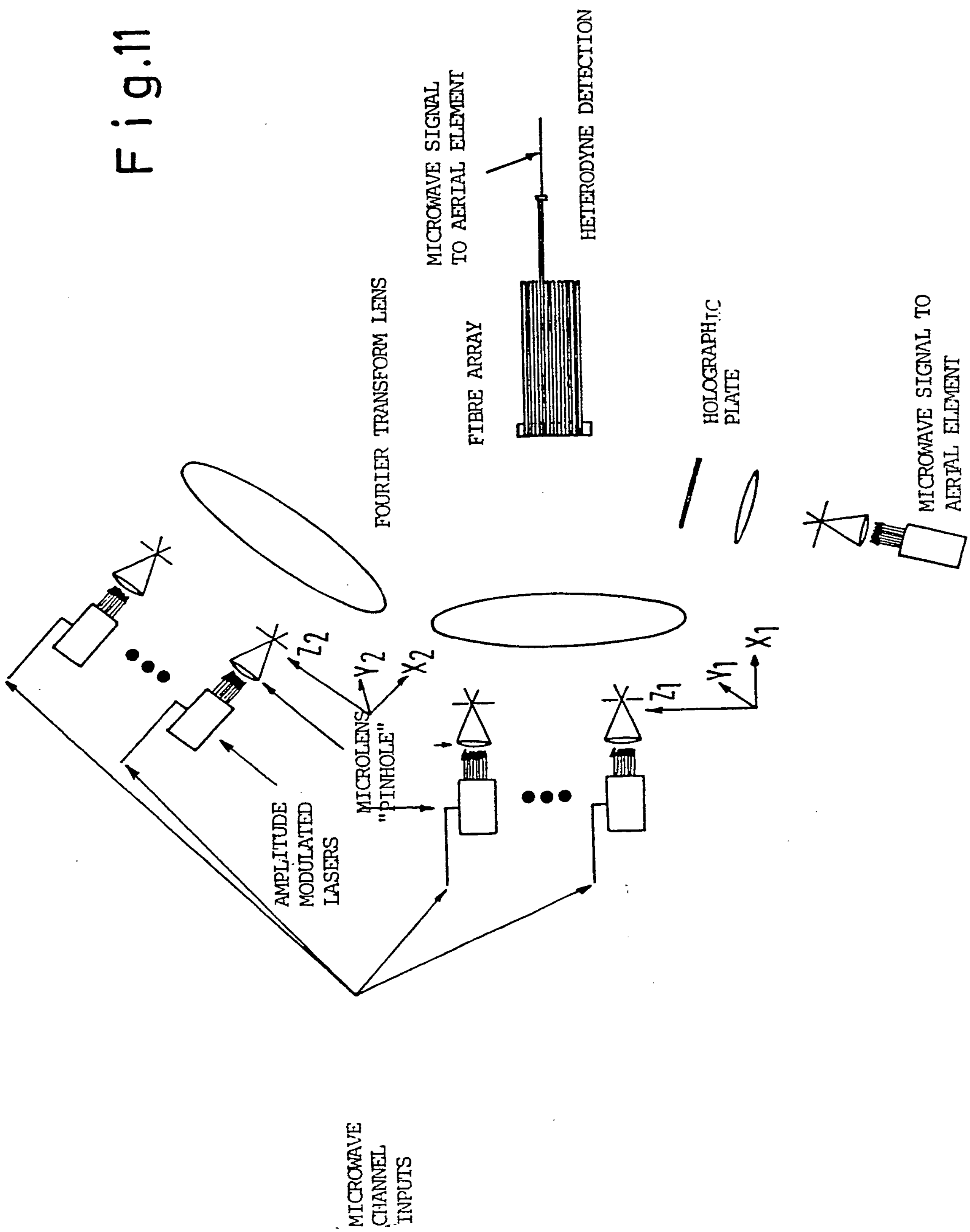
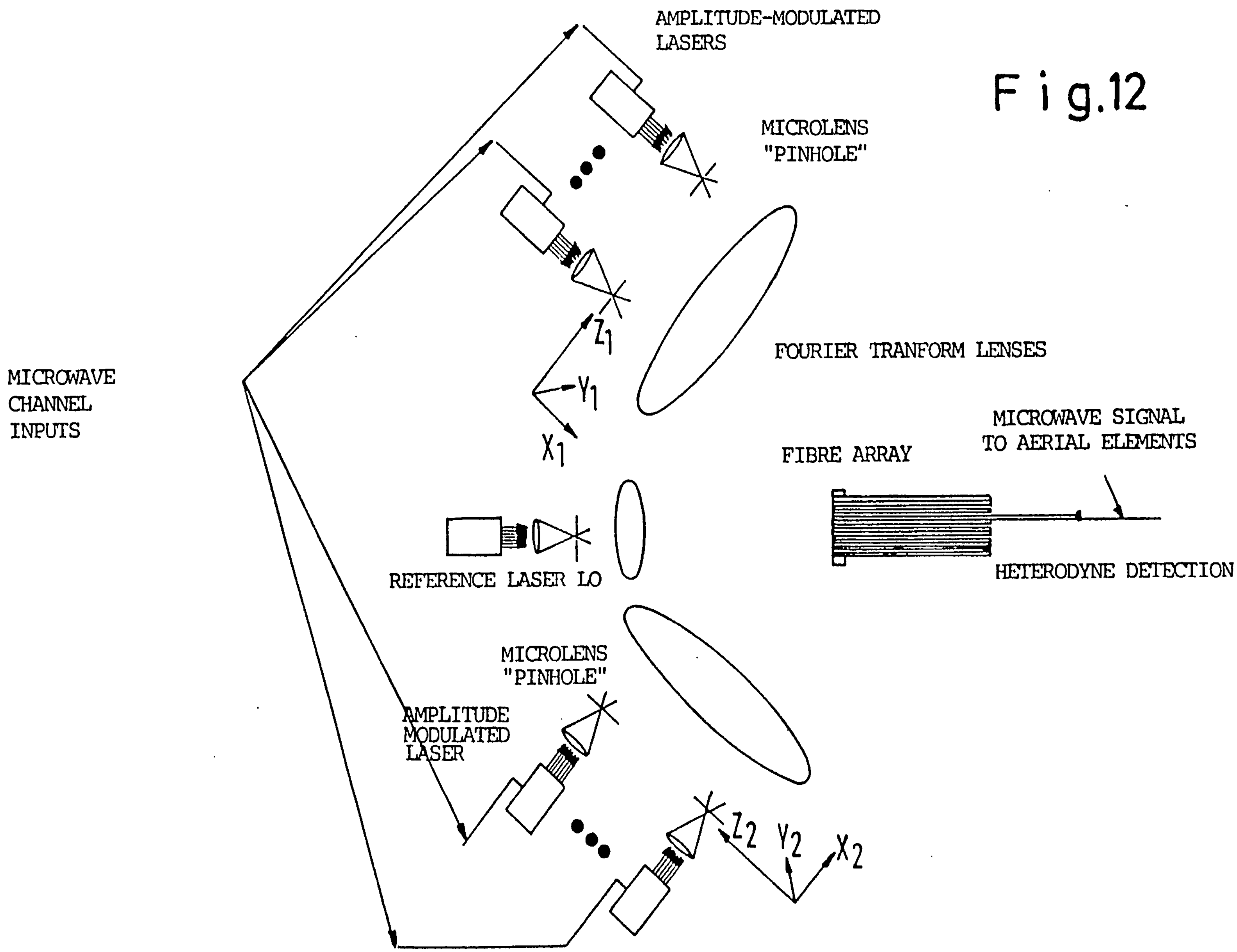

MICROWAVE SIGNAL
TO AERIAL ELEMENT
HETERODYNE DETECTION
FOURIER TRANSFORM LENS
FIBRE ARRAY
HOLOGRAPHIC
PLATE
MICROWAVE SIGNAL TO
AERIAL ELEMENT
Z_2
Y_2
X_2
X_1
Y_1
Z_1
MICROLENS
"PINHOLE"
AMPLITUDE
MODULATED
LASERS
MICROWAVE
CHANNEL
INPUTS

Fig.12



AMPLITUDE-MODULATED
LASERS
MICROLENS
"PINHOLE"
FOURIER TRANFORM LENSES
MICROWAVE CHANNEL INPUTS
Z_1
Y_1
X_1
MICROWAVE SIGNAL
TO AERIAL ELEMENTS
FIBRE ARRAY
REFERENCE LASER LO
HETERODYNE DETECTION
MICROLENS
"PINHOLE"
AMPLITUDE
MODULATED
LASER
Z_2
Y_2
X_2

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METHOD AND APPARATUS FOR THE SIMULTANEOUS GENERATION OF SEVERAL REAL TIME CONTROLLABLE AERIAL DIAGRAMS

The invention relates to a method for the simultaneous generation of several real-time controllable aerial diagrams and devices for carrying out said method.

The generation of an aerial diagram with phase-controlled active aerials has gained in importance in recent years. Each of these aerial elements transmits or receives microwave signals. The radiating properties (aerial diagram(s)) of the active aerial as a whole are determined by the radiating characteristics of the individual elements and their relative amplitudes and phases. The active aerial system as a whole consists of a beam-forming network with associated receivers/amplifiers. In transmitting operation, the aerial signal is beamed off by the radiating elements and in receiving operation the aerial signal is received by means of the radiating elements. In a transmitter aerial the beam-forming network (or networks) generate the signals for the radiating elements from the signals of a single or several microwave channels. In a receiver aerial the beam-forming network generates the signals of one or

several microwave channels by combining the signals of the radiating elements.

The object of the invention is to provide a beam-forming network which makes it possible to render the aerial control of multi-channel aerials more compact, simpler and cheaper than hitherto possible.

With this object in view the present invention provides a method for the simultaneous generation of several real-time controllable aerial diagrams, characterised in that the method employs an aerial composed of several directly emitting active microwave aerials and that the microwave aerials are controlled by an optical beam-forming network.

Advantageously the method includes the step of modulating a laser using the signal of an associated microwave channel for each aerial diagram.

Preferably the method is further characterised in that during transmission the signals are distributed in the optical beam-forming network by means of optical fibres to amplifiers arranged before the aerial elements and that the method includes the step of adjusting the directional characteristics of the individual aerial diagrams by means of restictors in the focal plane of the modulated laser.

Furthermore the method preferably includes the steps of combining the signals in the optical beam-forming network during reception by means of optical fibres, optically summing said signals and adjusting the

directional characteristics of the individual aerial diagrams by means of restrictors in the focal plane before the detectors.

Additionally the method is characterised in that the reference laser beam of the local oscillator LO is focussed by means of a holographic plate on the fibre cores of the fibre sheaf and is locked thereon.

Preferably the pivoting of the individual aerial diagrams is effected by lateral displacement in the y-z plane. Alternatively the pivoting of the individual aerial diagrams may be effected by lateral displacement of the laser "pigtails" in the y-z plane.

The method preferably includes switching the microwave channels to the modulation inputs of the different lasers or the switching of the pigtails between the different lasers to effect the pivoting of the individual aerial diagrams.

Advantageously the slewing of the laser beam is by way of electro-optical means to effect the pivoting of the individual aerial diagrams.

The method may be further characterised by the step of adjusting the contour of the main lobe of the aerial diagram by means of restrictors.

Where the reference laser beam is focussed by means of a holographic plate an advantageous modification includes a Fourier-optic consisting of a plurality of lenses for generation of the aerial diagrams.

Preferably the method also includes the step of laterally moving the local oscillator LO such that all aerial diagrams are pivoted simultaneously.

A further aspect of the invention provides apparatus for carrying out the method of the invention and all the advantageous modifications thereof.

In a preferred embodiment the apparatus comprises an aerial composed of several directly emitting active microwave aerials which are controlled by an optical beam-forming network.

Preferably the apparatus includes a laser which is modulated by a signal of an associated microwave channel for each aerial diagram. Additionally the apparatus may include restrictors operative to adjust the contour of the main lobe of the aerial diagram.

The invention will be described further, by way of example, with reference to the accompanying block circuit diagrams in which:_

Figure 1 of a known active aerial for a microwave channel;

Figure 2 of a beam-forming network according to the known prior art for a microwave channel;

Figure 3 of a known coherent optical beam-forming system;

Figure 4 of a known optical beam-forming system for receiver operation;

Figure 5 of a beam-forming network for transmitters of several microwave channels;

Figure 6 of a further embodiment of a beam-forming network for transmitters of several microwave channels;

Figure 7 of a third embodiment of a beam-forming network for transmitters of several microwave channels including electro-optical beam control;

Figure 8 of the object of Figure 7, with a local oscillator locked-on by way of a glass fibre;

Figure 9 of a beam-forming network for receivers of several microwave channels;

Figure 10 of a beam-forming network for transmitters/receivers of several microwave channels;

Figure 11 of a beam-forming network for transmitters of several microwave channels, utilizing a plurality of lenses; and

Figure 12 of a beam-forming network for transmitters of several microwave channels, utilising a plurality of lenses and a central local oscillator.

Figure 1 shows the block circuit diagram of a known microwave channel. Betweeen the microwave channel and the amplifiers for the individual radiating array

element is located a beam-forming network which is the object of the present invention.

A conventional beam-forming network is shown in Figure 2 and includes an aerial control, a distributor network, and amplitude adjuster elements. The aerial control calculates the setting of the phase shifters and of the amplitude adjuster elements. The computational expenditure required for this is so large, that real-time control of an aerial diagram in this way is very expensive using current State-of-Art methods.

A great number of methods are already available for handling the large data flow from the aerial control to the phase shifters and the amplitude adjuster elements.

When generating several aerial diagrams with conventional beam-forming networks, the formation of each aerial diagram of a transmitter or receiver channel requires a separate beam-forming network.

The aerial control consists of a digitial data-processing computer. The distributor network and the phase shifters can be constructed with microwave-components, as well as with optical and electrooptical components. By comparison with the optical and electro-optical construction, the construction of a distributor network with microwave components has the disadvantage of a large mass and large space requirement. It is therefore of interest to construct as many components as possible of the beam-forming network by optical means, thus saving up to 90 % in weight. To achieve this, it is necessary, to convert the microwave signal, at the inputs of the beam-forming network, into the optical range and to re-convert the optical signals back into the microwave-range at the output of the beam-forming network.

In Figure 2, the signal flow runs from left to right for a transmission channel. In this case, the signal of the microwave channel modulates the amplitude

of a laser beam. The optical signal is distributed by means of optical fibres. By detecting the optical signals, the latter are re-converted into the microwave range. When the phase shifter and the amplitude adjuster element are constructed with microwave components, the optical signal is detected prior to the phase shifter. If the phase shifter is constructed with optoelectronic means, the optical signal is detected after the phase shifter. If the amplitude adjuster element is also constructed with optoelectronic means, which, however, is not possible in the current State of the Art, the optical signal is detected after the amplitude adjuster element.

In the conventional systems the phase shifters and the amplitude adjuster elements are constructed either with microwave components or also with optical components. Since it is difficult to construct the phase shifters and the amplitude adjuster elements with optical means, it is advantageous with the current State of the Art to integrate them in the amplifiers of Figure 1 and to effect the phase- and amplitude-adjustment in the microwave range.

In Figure 2, the signal flow in a receiver channel runs from right to left. The microwave signals of each radiating element amplitude-modulate a laser beam. The individual optical signals are transmitted by means of

optical fibres and are so combined and detected, that the demodulated microwave signals are summed with the correct relative phases.

In the conventional electro-optical systems, the signals between the microwave channels and the radiating elements, the phase shifters and the amplitude adjuster elements are often distributed by means of fibre optics. However, aerial control is effected by means of a computer. The distribution of the signals from the aerial control to the phase shifters is likewise effected by way of a fibre optic.

Since the calculation of the aperture loading of the radiating elements with phases and amplitudes is in fact a Fourier transform, it prompts the concept of carrying out the Fourier transformation by means of a Fourier optic. In a Fourier-optic beam-forming system it is in principle possible to construct with optical means not only the distributor network, but also the aerial control. Such a system is known in principle and has been described in:

Koepf, G.A., Optical Processor for Phased-Array Antenna Beam Formation, SPIE, Vol. 477, pp. 74-81, 1984.

The method described in the cited publication utilizes a fibre-optic distributor network for the transmitter system only. For reception, use has to be made of a summation of the signals with microwave components.

An embodiment of this concept, beyond experimental arrangements, is not known from publicly available literature. For the sake of better understanding, the method will be explained in more detail, first for transmitting operation and then for the receiving operation.

In contrast to Figure 2, in the cited publication signal distribution, aerial control, phase- and amplitude adjustment are replaced by a Fourier-optic system. Figure 3 is drawn from the above-cited publication and shows a block circuit diagram for a phase-controlled transmitter aerial. The signal of the microwave channel is converted into the optical range, as it modulates the electro-optic modulator. The aerial control, the phase shifters and the amplitude adjustment of Figure 2 are replaced by the Fourier-transform lens "FT-Lens" and the optical mixing of the microwave-modulated laser light with the coherent light of a further laser. The interference pattern generated, which contains the data of the aperture loading of the array elements with amplitude and phase, is transmitted by fibre optic from the beam-forming network to the array elements.

In Figure 4, which is likewise drawn from the above cited publication, the same optical beam-forming network is utilized for the reception channel as in Figure 3, without modulation of the electro-optic modulator.

In this case, the beam forming network is still optical but the dustribution and summation of the signals is effected by microwave components. By the detection of the optical signals of the outputs of the optical beam forming network, a series of coherent microwave signals f_{IF}, is generated, of the same frequency but with different of the same frequency but with different phases, is generated. Each of these signals f_{IF} is assigned as local cf all array elements are mixed with the associated local oscillator frequency f_{IF} and added up. In other words, the distributor network and in this case the "summation network" of the receiver channel is realized in the microwave range and is therefore much heavier than an optical network, with a correspondingly larger space requirement.

Since the distribution network for reception has to be constructed with microwave components, the above-decribed concept does not offer the advantages of low weight and space requirement by fibre-optic transmission of the microwave signal for the receiver system. Moreover, this method is usable only for the formation of a single aerial diagram (for transmission or reception).

Both of these disadvantages are avoided by the present invention, that advantages and possibilities of which will be explained in the following.

To achieve a light and compact beam forming system, it is useful to have the entire beam formation for both the transmitter and the receiver system carried out by means of an optical beam-forming network and also for the signal distribution to be effected by means of optical fibres. This cannot be achieved with the method of the above-cited publication. By applying the here proposed novel method according to the invention, it becomes possible to generate several real-time controlled aerial diagrams, in order to transmit or receive with the phase-controlled active aerial several channels from or in the same or different directions.

The method proposed above is based on an optical beam-forming network for an aerial diagram with a fibre-optic distribution for transmitter operation. The object of the invention is characterised by two additional advantageous properties, namely, by the possibility of generating several real-time controllable aerial diagrams for the simultaneous transmitting or receiving operation of several microwave channels from the same or different directions and further by the possibility of applying fibre-optic signal distribution not only for the transmitting but also for the receiving operation, owing to which the beam forming system is very

compact and light.

In order to generate several aerial diagrams for transmitting operation, several modulated lasers are utilized. The signal of the microwave channel modulates one laser for each aerial diagram (see Figures 5, 6, 7).

The pivoting of the individual aerial diagrams can, as shown in Figure 5, be effected by laterally moving the laser in the y-z plane, but also, as shown in Figure 6, by laterally moving the "pigtails" of the laser on the y-z plane. Further, the pivoting can be effected by switching the microwave channels to the modulation inputs of the different lasers or by switching the pigtails between the different lasers, e.g. by fibre-optic switches.

All optical fibres utilized for distribution or combination must be monomodal fibres. Since the diameter of the outlet aperture of the fibre is directly proportional to the lobe width of the aerial diagram, the beam in the fibre must be correspondingly widened by means of an optic placed before the fibre end. During irradiation of the fibre sheaf with the modulated and the reference-laser light, only a small portion of the light impinges on the inlet aperture (fibre core) of the optical fibres. The reference-laser beam of the local oscillator LO is focussed either by means of a beam divider or with a holographic plate on the fibre

cores of the fibre sheaf and locked on. In order to simplify the explanation of the method, it is assumed here that the wave-/phase front of the local oscillator LO is plane parallel to the aperture of the fibre sheaf with respect to the array elements. By a corresponding phase shift of the microwave signals with respect to the array elements, the angle of the wave/phase front may also be different. The "fundamental wave lengths" of the modulated laser and of the local oscillator LO are coupled with each other.

If the local oscillator LO is locked on not by means of a holographic plate but by way of a beam divider, then all the aerial diagrams can be pivoted simultaneously by laterally moving the local oscillator LO.

Instead of moving the modulated laser or fibre ends of the "pigtails" in the y-z plane, as shown in Figures 5 and 6, the laterally displaceable laser beam can also be generated by the use of an additional fibre sheaf, in particular possibly by the fibre sheaf 1 in Figure 7 In this arrangement, the position of the individual lasers is fixed and the laser beam is guided by an electro-optical beam deflector to a fibre which corresponds to the desired position of the laser beam in the y-z plane. This method makes possible a rapid pivoting of the aerial diagrams. By means of an optic

placed in front of the fibre inlet aperture, the efficiency of the laser beam lock-on into the fibres of fibre sheaf 1 can be increased. At the emergence of light from the fibres in the sheaf 1, it is important to have an envelope as thin as possible relative to the core, in order to achieve a high angular resolution of the aerial diagrams. Since here the diameter of the outlet aperture is again proportional to the lobe width of the aerial, the beam in the fibre must be correspondingly widened out by means of an optic placed before the fibre ends.

Figure 8 shows how the local oscillator LO can be locked on through the fibre sheaf 1 preceding the Fourier transform lens. The local oscillator LO (laser or laser group, "laser array") is so focussed on a fibre, that a wave-/phase front parallel to the inlet aperture is generated in the focal plane of fibre sheaf 2.

In order to generate, according to Figure 9, several aerial diagrams for receiving operation, the microwave -modulated optical signals of the optical fibres of each array element are amplified by one laser each. It is important to have the "fundamental wavelengths" coupled with each other. Since a coherence of the laser beams in the "pinhole plane" is indispensable, the use of optical fibres following the laser in analogy with beam-forming network for the transmission system of

Figure 1 is inadvisable. In the case of a temperature gradient along the glass fibres, the fibres expand differently and thereby destroy the coherence of the optical signals. Instead, the lasers should radiate in the focal plane through "pinholes". Behind the Fourier optic, the signal of a microwave channel with the associated aerial diagram is picked up by a detector each. For beam deflection, it is in principle possible to move the detectors in analogy with the lasers, but it is simpler to cover all possible microwave channels or aerial diagrams with a detector array and then select the desired microwave channels or aerial diagrams by means of a multiplexer. Since the laser beams interfere with each other in the detector plane, an additional coupling in of a reference beam, e.g. that of local oscillator LO, is not necessary, but can be applied, in order to detect the modulated optical signals with an increased sensitivity.

If the same beam-forming system is to be used for the transmitter and the receiver system, this is possible by utilizing fibre sheafs before and after the the Fourier-transform lens, as shown in Figure 10. In transmitter systems, the signals of the amplitude-modulated laser are decoupled from the optical fibres with laterally displaceable fibre ends, as in Figure 6. The fourier-transformed signals are coupled

into a fibre sheaf, as in Figures 5, 6 and 7. However, in this case the mixing with the local oscillator LO is effected with a 3-dB coupler in the fibres. During reception, the local oscillator lasers LO are commuted and serve as laser-amplifiers for the optical signals coming from the array elements. These signals are subjected to Fourier-transformation, coupled into the pigtails as shown in Figure 10 and picked up by a detector As before, the diameters of the inlet and outlet apertures are of decisive importance for the lobe width of the aerial diagram.

The contour of the main lobes of the aerial diagrams of a transmitter system can be adjusted by restrictors in the focal plane of the modulated laser. In this case, the restrictors replace the "pinholes". A variation of the contour can be achieved by varying the restrictor. The restrictor may be mechanical, or may be formed of an electro-optical component, such as an LCD-matrix.

Another possibility for contour formation consists in combining several individual diagrams.

The contour of the main lobes for a receiver system can be adjusted in an analogous manner by restrictors in the focal plane of the detectors. Here again a variation of the contour can be achieved by varying the restrictor. This restrictor can likewise be a mechani-

-cal or may be formed of an electro-optical component such as a LCD-matrix.

Another possibility for contour formation consists again of the combination of several individual diagrams

Several aerial diagrams can also be generated with a plurality of lenses. Figure 11 shows two laser groups which may consist of one or several lasers. This arrangement is also possible for more than two laser groups. Figure 11 shows only one local oscillator laser LO for all modulated lasers. It is also possible to use for the lasers of each group a separate wavelength and a separate local oscillator LO. If each local oscillator LO is not coupled in through a holographic plate but through a beam divider, then by moving the local oscillator LO the group of the associated aerial diagrams can be pivoted. The methods according to Figures 6, 7 and 8 are also applicable to the arrangement shown in Figure 11.

The invention also proposes a novel method, by which several real-time controllable aerial diagrams can be generated. This method differs essentially from the method of the prior publication discussed in detail by the control of the aerial diagrams, which makes possible a simultaneous operation of several channels and by the more efficient coupling-in of the local oscillator LO through a holographic plate. Neither the transmitter nor the receiver system of the invention is made

up of microwave components, but with optics and electro-optics. For this reason, the method fundamentally differs from the concept of the cited publication. In the method here proposed, only optic and electro-optic components are utilized for the beam formation of several real-time controllable aerial diagrams. Owing to this, the method is superior to all conventional systems in terms of compactness and lightness.

CLAIMS

1. A method for the simultaneous generation of several real-time controllable aerial diagrams, characterised in that the method employs an aerial composed of several directly emitting active microwave aerials, and that the microwave aerials are controlled by an optical beam-forming network.

2. A method according to Claim 1, including the step of modulating a laser using the signal of an associated microwave channel for each aerial diagram.

3. A method according to Claim 2, characterised in that during transmission the signals are distributed in the optical beam-forming network by means of optical fibres to amplifiers arranged before the aerial elements and that the method includes the step of adjusting the directional characteristics of the individual aerial diagrams by means of restictors in the focal plane of the modulated laser.

4. A method according to Claim 3, including the steps of combining the signals in the optical beam-forming network during reception by means of optical fibres, optically summing said signals and adjusting the directional characteristics of the individual aerial diagrams by means of restrictors in the focal plane before the detectors.

5. A method according to Claim 4, characterised in that

the reference laser beam of the local oscillator LO is focussed by means of a holographic plate on the fibre cores of the fibre sheaf and is locked thereon.

6. A method according to Claim 5, characterised in that the pivoting of the individual aerial diagrams is effected by lateral displacement in the y-z plane.

7. A method according to Claim 5, characterised in that the pivoting of the individual aerial diagrams is effected by lateral displacement of the laser "pigtails" in the y-z plane.

8. A method according to Claim 5, including the step of switching the microwave channels to the modulation inputs of the different lasers or the switching of the pigtails betweeen the different lasers to effect the pivoting of the individual aerial diagrams.

9. A method according to Claim 5, including the step of slewing of the laser beam by electro-optical means to effect the pivoting of the individual aerial diagrams.

10. A method according to Claim 1, characterised by the step of adjusting the contour of the main lobe of the aerial diagram by means of restrictors.

11. A method according to Claim 5, characterised in that several aerial diagrams are generated by means of a Fourier-optic consisting of a plurality of lenses.

12. A method according to Claim 3, characterised by the step of laterally moving the local oscillator LO such that all aerial diagrams are pivoted simultaneously.

13. A method substantially as hereinbefore described

with reference to and as illustrated in the accompanying drawings.

14. Apparatus for the simultaneous generation of several real time controllable aerial diagrams comprising an aerial composed of several directly emitting active microwave aerials which are controlled by an optical beam-forming network.

15. Apparatus as claimed in Claim 14, including a laser which is modulated by a signal of an associated microwave channel for each aerial diagram.

16. Apparatus as claimed in Claim 14, further including restrictors operative to adjust the contour of the main lobe of the aerial diagram.

17. Apparatus according to Claim 15, characterised in that during transmission the signals are distributed in the optical beam-forming network by means of optical fibres to amplifiers arranged before the aerial elements and that the directional characteristics of the individual aerial diagrams are adjusted by means of restrictors in the focal plane of the modulated laser.

18. Apparatus according to Claim 17, characterised in that during reception in the optical beam-forming network the signals are combined by means of optical fibres, are optically summed and that the directional characteristics of the individual aerial diagrams are adjusted by means of restrictors in the focal plane before the detectors.

19. Apparatus according to Claim 18, characterised in

that the reference laser beam of the local oscillator LO is focussed by means of a holographic plate on the fibre cores of the fibre sheaf and is locked on.

20. Apparatus according to Claim 19, characterised in that the pivoting of the indiviudal aerial diagrams is effected by lateral displacement in the y-z plane.

21. Apparatus according to Claim 19, characterised in that the pivoting of the individual aerial diagrams is effected by lateral displacement of the laser "pigtails" in the y-z plane.

22. Apparatus according to Claim 19, characterised in that the pivoting of the individual aerial diagrams is effected by switching of the microwave channels to the modulation inputs of the different lasers or by the switching of the pigtails between the different lasers.

23. Apparatus according to Claim 19, characterised in that the pivoting of the individual aerial diagrams is effected by an electro-optical slewing of the laser beam.

24. Apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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